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PUTTING A SEWAGE TREATMENT PLANT INTO OPERATION

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SANITARY ENGINEERING DIVISION

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PUTTING A SEWAGE TREATMENT PLANT INTO OPERATION

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Putting a Sewage Treatment Plant in operation starts with the original design and continues until the operating conditions are relatively normal or stabilized. This paper describes the procedures used in connection with the North Point and Southeast Sewage Treatment Plants of the City of San Francisco, which were placed in operation in December, 1951.

These plants are part of a master plan having as its objective the treatment of all sewage discharged into the surrounding bay or ocean waters. The master plan is based on a program recommended in a report to the Director of Public Works in 1935, by a Board of Consulting Engineers consisting of the late Harrison P. Eddy, Charles Gilman Hyde, Leon B. Reynolds and the late Clyde C. Kennedy. Their recommendations have been generally followed except that the degree of treatment required has been changed to meet current standards of quality and conditions at outfalls, prescribed by the State Department of Public Health and the Water Pollution Control Boards. All of the plants provide primary treatment with sufficent chlorination of the effluent to reduce the number of coliform organisms in the recreational shore areas to less than 10 per milliliter 80% of the time.

Sewage of San Francisco is at present treated in two plants, the Richmond-Sunset and the North Point. A third plant known as the Southeast is under construction. Figure 1 shows the plant locations and tributary areas.

The Richmond-Sunset Plant was constructed in 1938 and enlarged in 1948. This plant, with a design capacity of 20 mgd, treats the sewage from the westerly residential area, with an estimated ultimate population of 300,000. The plant provides pre-chlorination for odor control, screening by coarse and fine bar screens, removal of grit and grease from aerated Imhoff Type grit-grease tanks, pre-flocculation by mechanical means, sedimentation and post chlorination of the effluent before discharge to the ocean.

Sludge removed from the sedimentation tanks, together with grease, is thickened, digested in two-stage digesters, elutriated and filtered by vacuum units. At present the filtercake is hauled to city parks for use as a soil conditioner but will be hauled to the Southeast Plant to be dried in the future. Screenings are incinerated and grit and sand is hauled to a city dump.

Construction was started on the North Point Sewage Treatment Plant in 1949 and completed in 1951 at a contract cost of about $8.5 million. This is a primary treatment plant without sludge treatment facilities, handling sewage and industrial wastes from combined sewers from the northeasterly section of the city. The sludge is pumped across town six miles to the Southeast Plant.

The plant has a design capacity of 65 mgd from an estimated ultimate population of 835,000 with a maximum capacity of 150 mgd including the run-off from light rains. Light rains are treated to prevent contamination of the

recreational shore areas particularly during the summer months. Provision is made for discharge directly to the bay for excessive storm flows or for all flows when the plant is by-passed.

Figure 2 is a Flow Diagram showing plant capacity and method of treatment.

Two contracts were let in 1949 and 1950 totaling about $7.0 million for the Southeast Sewage Treatment Plant. There are actually two separate plants on one site, one for sewage treatment and the other for sludge digestion, filtration and drying. The sewage treatment part has a design capacity of 30 mgd and will treat sewage from combined sewers from an estimated population of 400,000. The type of treatment employed at this plant is similar to that at the North Point Sewage Treatment Plant.

The sludge handling facilities include thickening of the raw sludge from the North Point and Southeast Plants, primary and secondary digestion in digesters with floating covers, primary and secondary elutriation, vacuum filtration, heat drying and pelletizing of the dried sludge. The filter cake from the Richmond-Sunset Plant will be dried with the filter cake from this plant.

Figures 3 and 4 are Flow Diagrams showing plant capacity and method of treatment for the sewage treatment and sludge handling facilities respectively.

About $3.0 million has been expended for connecting trunk and outfall sewers to the two new plants and for the cross-town sludge force main. An additional $6.0 million will be spent from available funds for constructing pumping plants and to convey sewage to the plants now discharging directly to the bay. On completion of this program, the city will have expended nearly $30,000,000 for sewage treatment. All of the funds have been obtained from general obligation bond issues with some State aid.

The North Point Sewage Treatment Plant was designed by the Bureau of Engineering of the Department of Public Works. The Southeast Sewage Treatment Plant was designed by the Engineering Office of C. C. Kennedy, which also served as consultant on the general program and on the design of the North Point Sewage Treatment Plant. Trunk sewers, outfalls and pumping plants were or are being designed by the Bureau of Engineering.

The steps taken and the procedures used in putting the plants in operation embody:

1. Planning for operation in design and specifications.
2. Obtaining intimate knowledge of plant layouts.
3. Estimating cost of operation.
4. Procurement and training of personnel.
5. Procurement of equipment and supplies required for operation.
6. Preliminary testing of the plants.
7. Initial operation.
8. Making changes required in plant and equipment.
9. Determination of quantity and character of materials to be handled.
10. Setting up normal operating procedures.

1. Planning for Operation in Design and Specifications.

Every effort was made during design of the plants to study and analyze the layouts from the standpoint of operation, utilizing the experience gained at the Richmond-Sunset Plant. Particular consideration was given to the following factors:

Maintenance requirements for plant and equipment.
Working space around units and for removal of units.

Lifting facilities such as hooks embedded in the concrete, hoists, and or other means.
Sampling.
Duplication of units.
Automatic vs manual operation.
By-passes.
Power operation of large gates.
Water for cleaning and flushing, cleaning of channels, tanks, etc.
Protection around openings and walkways.
Adequate lighting.
Ventilation.
Safety facilities.
Tool Boards at convenient locations.
Inter-plant communication and signal systems.
Alarms.
Coding of pipes.
Facilities for employees - showers and locker rooms, toilets, lunch rooms, etc.

2. Obtaining Intimate Knowledge of the Plant Layouts.

The Division of Sewage and Waste Treatment is a line function reporting directly to the City Engineer. As division engineer, I was assigned during the early stages of construction to act as coordinator between the city engineer and the consulting engineer, to keep fully informed on construction of the plants and to recommend changes as might be required to fit operational requirements. This assignment made it possible to become intimately acquainted with the new plants, to be in a position to study operational needs and to make recommendations for changes during construction. Other supervisory personnel in the Division were also given the opportunity to become acquainted with the plants. Their knowledge was utilized in determining the costs of operation, setting up operating procedures and training personnel for employment at the new plants.

3. Making Estimates of the Costs of Operation.

City and other officials often do not realize the costs involved in operation. It is therefore necessary to start early in bringing these matters to their attention to obtain adequate funds. As funds in San Francisco are budgeted in advance on a fiscal-year basis, budget estimates for the plants were made about one year ahead of the scheduled time of completion. It was necessary to determine number and classification of personnel required, materials and supplies to be purchased and not included in the contract, services of other agencies and new equipment. Our budget for Sewage Treatment Plant Operation is set up by the following items;

Monthly Personnel

Yearly base salary
Vacation leave relief, sick leave relief
Temporary salaries
Overtime
Holiday pay

Wages

Yearly base pay
Overtime
Vacation leave relief, sick leave relief
Temporary employments

Materials and Supplies

Replacement and spare parts
Plant supplies
Shop supplies
Stationery and office supplies
Tires, tubes and auto supplies
Fuels and lubricants

Contractual Services

Engineering by Work Order to Bureau of Engineering
Building trades (electrical, plumbing, painting, sheet metal work, carpentry, etc.) by Work Order to City Shop.
Shop work, by Work Order to City Shops
Miscellaneous services
Subscriptions
Automobile allowance for employees cars.
Maintenance of landscaped areas by Work Order to Park Department
Maintenance of automotive equipment by City Shops.
Heat, Light and Power.

4. Procurement and Training of Personnel.

Before procuring and training personnel for the new plants, it was decided to use the same general organization as had been employed successfully for many years at the Richmond-Sunset Plant. Each plant has a superintendent-in-charge, an engineering classification, with two sub-sections, laboratory and operation and maintenance. The laboratory section is headed by a chemist, sewage treatment, with the required number of assistants who do routine laboratory work.

The operation and maintenance section is headed by a chief operating engineer, an operating classification. This section has five operating engineers as shift leaders, one or more operating engineers for maintenance and the required number of junior operating engineers. Laborers, truck drivers and janitors report to the chief operating engineer or are assigned to an operating engineer.

On this basis the North Point Plant has 33 and the Southeast Plant has 37 employees in the following classes:

North Point

1 Superintendent, Sewage Treatment
1 Clerk Stenographer
1 Chemist, Sewage Treatment
2 Laboratory Assistants (1 routine analyses, 1 bacteriological)
1 Chief Operating Engineer
6 Operating Engineers
15 Junior Operating Engineers

4 Laborers
1 Truck Driver
1 Janitor

Southeast Plant

1 Superintendent, Sewage Treatment
1 Clerk Stenographer
1 Chemist, Sewage Treatment
3 Laboratory Assistants (routine analyses)
1 Chief Operating Engineer
7 Operating Engineers
27 Junior Operating Engineers
5 Laborers
1 Janitor

All employees are procured from Civil Service lists and must be residents of the city. The position of superintendent is promotional from chemist, sewage treatment, and from engineering lists of a lower pay rate, while those of chief operating engineer and operating engineer are promotional from operating engineer and junior operating engineer respectfully. Lists for operating personnel are for general City service and not specifically for sewage treatment plants. The Civil Service Commission was advised in sufficient time to conduct examinations so that the number of employees required would be available when needed. Funds were requested and obtained in the budget to provide a training period for certain classifications before placing the plants in operation. The purpose of this was to acquaint the personnel with the operation of sewage treatment plants in general and with the details of their job assignments as most had no previous experience in sewage treatment plant operation.

Training schedules provided for were three months for superintendents and chemists, six months for chief operating engineers, two months for operating engineers, one month for junior operating engineers and laboratory technicians, and none for the other employments. Actually these training periods were exceeded as the plants were not completed on schedule.

All employees to be trained were first assigned to the Richmond-Sunset Plant where they received instruction from the superintendent, chemist, or chief operating engineer, depending on their jobs. This training period extended from about one week to one month for the operating classifications and from one to three months for the chemical classifications. The superintendents, who had previously been employed as chemists, trained the chemists who then served as instructors for the laboratory technicians.

On completion of the training at the Richmond-Sunset Plant, the men were assigned to their respective plants for on the job instruction.

The chief operating engineer was the first employee assigned to each new plant so that he could become sufficiently familar with details of the plant layout, to be able to instruct new operators in care and maintenance of equipment and to assist inspection forces and obtain information on equipment from manufacturers' representatives.

Superintendents and chemists were next assigned. They first familiarized themselves with the details of the plants, then set up the training program for new personnel in cooperation with the chief operating engineer, and determined the operating procedures to be followed when the plant went into operation.

When operating engineers were assigned, they received instructions from the chief operating engineer on the general plant layout and equipment, assisted in marking and identification of the piping, checking of supplies and conducting preliminary tests.

Junior operating engineers were assigned about one month after the operating engineers. Each operating engineer served as an instructor to a small group of junior operating engineers. The junior operating engineers were first trained in their particular job assignments, and then were given as much information as possible on other details of the plant.

Frequent conferences were held, and sketches and drawings showing the piping details were used as training aids. These conferences allowed supervisory personnel to become better acquainted with operator's qualitications and to make proper work assignments. Every effort was made to answer all questions brought up by operating personnel.

Particular attention was given to directions on steps to be taken in event of an emergency, such as power failure, overloading, breakage, stoppage or other incidents.

On completion of the training program all of the plant personnel assisted in making the preliminary tests.

5. Procurement of Equipment and Supplies Required for Operation.

Only part of the plant, shop, laboratory and office supplies and equipment needed for operation were included in construction contracts. The balance were obtained before starting the plants through the use of bond funds for fixed items and plant funds for others. No attempt was made to stock up on the supply items which should normally be purchased on a year to year basis after actual requirements are known.

6. Preliminary Testing

The construction specifications provided for testing and checking of all equipment by the contractors before initial operation and for submission of a statement by equipment manufacturers that their equipment was correctly installed and ready for operation.

It was decided that it would be to the advantage of the City and to the contractor to have this preliminary program made a joint venture of both parties. Accordingly a schedule was laid out by City inspection forces with the cooperation and approval of the individual contractor and city operation and design forces. Fresh water was used when ever possible to check pipe lines, tanks for leaks, pumps and other equipment for performance. This made it possible to correct any difficulties before placing the plant in initial operation. The inspectors made out a test check schedule for each building or group of buildings which constituted a stage in the process. Each schedule listed all specification test requirements for mechanical and electrical equipment, piping, etc., as well as detailed step by step test procedures. The following program was followed at the North Point Sewage Treatment Plant and for all units at the Southeast Sewage Treatment Plant except the sludge filtering and drying facilities.

(a) All equipment was checked for a conformity to the approved drawing and specifications.
(b) All electric circuits were checked.
(c) Tanks, as required, were calibrated to determine quantities for measurements.

(d) Water systems were checked.
(e) Air systems were checked.
(f) All hydraulic gates were operated with water.
(g) Sedimentation tanks were filled with water and this water circulated through the plant for checking operation of pumps, motors, flights, etc., and tightness of pipe lines and that the water was discharging where required.
(h) Lighting systems were checked.
(i) Ventilation systems were checked.
(j) A check was made of miscellaneous equipment.

At the Southeast Sewage Treatment Plant digesters were filled with water over the corbels and the water circulated through the units. The check of the filtering and drying system had to be delayed until sludge was available.

As a result of the preliminary tests a number of changes and corrections were made which were the contractor's responsibility. This preliminary testing was in a good measure responsible for the success of the initial operating period.

7. Initial Operation

Specifications required that the City place the plants in operation for a 30 day test period after completion of the preliminary tests and furnish the operating staff water, power, chemicals, etc. The contractor was required to instruct and supervise the operating staff in the care and operation of the equipment, to make any changes necessary to comply with the specifications or to replace any defective material, and to assume all responsibility for any damage to plant or equipment during this period.

Based on past experience, it was deemed advisable to operate one unit at a time and to place all units in operation gradually as conditions and experience warranted. In the beginning as many units as possible were operated during the day period. Twenty-four hour continuous operation was started as soon as conditions were uniform and necessary corrections made. This method allowed for concentration of forces, more extensive training of employees and a minimum amount of confusion.

Design of the plants is based on assumed basic design factors which in many cases are quite different from those obtained during actual operation. During this initial operating period the quantity of the flow, the strength and character of the sewage, and materials removed were determined and operating problems evaluated. The duty assignments for personnel were changed as required to meet the needs.

Sample forms were prepared to record pertinent data before the start of the initial operation period so that adequate records could be kept for evaluating the quantity and character of the sewage and sludge and for controlling operation of the equipment and process. Certain readings are required at regular intervals to be sure that operators are actually observing and checking the operations. No attempt was made to set up normal sampling procedures during this period, as only sufficient information was desired to determine how the units were operating and to check on the specification requirements.

At the North Point Plant sewage was first run through one bar screen and grit tank. After it was shown that the influent control gates were operating properly other grit tanks were gradually placed in service so that at the end of one week all of the tanks had been operated singly or in combination with others.

Each of the two pump sumps were operated separately and the sump scum skimmers and grit and sand removal equipment were checked. The controls for automatically cutting the main lift pumps in and out were adjusted so that the pumping rate followed the influent flow rate as closely as possible.

Discharge from the pumps was run through one sedimentation tank at a time and the operation of the air floculation system and the flights observed, and necessary adjustments made. The number of sedimentation tanks in service was gradually increased as conditions permitted so that at the end of the 30 day period all of the tanks were in service.

All flow metering equipment was checked to test correlation between the influent and effluent metering and meter control of chlorination. All auxiliary equipment such as air deodorizing systems, effluent filters, automatic samplers, etc. were checked and adjusted during the thirty day period. The laboratory was set up and studies and testing of the sewage and sludge was started and sampling schedules determined.

Chlorination system was not started until near the end of the thirty day testing period. Before starting, the storage tanks were filled with dry air for one week and air then removed. Then two one-ton cylinders of chlorine were connected to the system and the lines checked and the units adjusted. On completion of these preliminaries, a tank car of chlorine was transferred to permanent storage. Chlorination units were tested at low dosage and the dosage was increased after final adjustments were made by the manufacturer.

During this initial operating period the sludge removed from the sedimentation tanks was pumped directly to the bay with the effluent. Before pumping sludge through the cross-town line to the Southeast Plant the line was checked for leaks by filling with effluent and for obstructions by forcing a chain-covered rubber ball through the line. Sludge was not transferred through the line until a sufficient quantity of seeding material was available in the digestion system at the Southeast Plant in order that digestion could proceed under most favorable conditions and without the possibility of foaming.

The starting of the digestion system at the Southeast Plant is of special interest. One primary digester was seeded with 1,000,000 gallons of digested sludge hauled from the Richmond-Sunset plant in 5,200 gallon tank trucks during a thirty day period. Before adding the seeding material, the digester was heated to 95°F using natural gas and this temperature has been maintained. Raw sludge was added when 500,000 gallons of seedling material had accumulated in the digester in an amount equal to ten percent of the solids loading in the digester and this ratio was maintained as the amount of solids in the digester increased. Thirty days after seeding operations began, a total of 60,000 pounds of raw sludge was being added to the three digesters per day.

Gas production from the seeded digester was first noticed on the eighth day after the start of the seeding sludge transfer. A total of 3600 cu. ft. of gas was recorded for the 24 hour period, ten days after seeding operations began. Gas production reached 125,000 cu. ft. per 24 hours six days after feeding with raw sludge began and thereafter the amount of gas production reflected the load of raw sludge added to the digesters. Digester gas was used for heating the digesters and dryers after February 15, 1952.

Starting in March 1952, supernatant and bottom sludge from primary digesters were transferred to the secondary digesters with intermediate single-stage elutriation until by the middle of April and there was sufficient storage of digested sludge to permit operation of one dryer at rated capacity for thirty days. During this time digester conditions were checked by volatile acid determinations, alkalinity, volatile matter, pH, and composition of gas.

During March all auxiliary equipment for the filters was checked to make sure it was operable. This was done by our own organization in cooperation with representatives of the Oliver United Filter Company. After this check, filter drums were soaked by revolving continuously in a bath of water for 168 hours, and the filter cloths were then installed. Production of filter cake, using elutriated sludge, was started on April 7 as scheduled, and was continued on an intermittent basis to check and adjust secondary elutriation, filtration and conveying equipment under operating conditions, to insure a steady and adequate supply of filter cake for drying and to determine the nature of the filter cake produced. In one week the filters were operating satisfactorily and it was possible to start the dryer tests.

The representative of Combustion Engineers Superheater, Inc. reported to the plant two weeks prior to the scheduled date of dryer operation. During this time he tested the electric circuits, dryer controls and motors with the cooperation of City electrical and mechanical inspectors and plant operating personnel. Plant operators were rotated during this period to familiarize as many men as possible with this equipment.

Dryer operation was started on April 14 as scheduled. Each dryer was operated on an 8-hour basis for three weeks and then for one week continuously as a shakedown. During this six weeks operation, frequent meetings of operating personnel and the representative of Combustion Engineers Superheater Inc. were held to bring out comments, critizisms and questions. In addition to familiarizing the operators with the equipment, the preliminary operations had the following objectives:

(a) Check and adjustment of all components of the system.
(b) Development of proper operating procedure, especially in connection with starting and stopping of the dryers, and coordination between the operation of the filters and dryers.
(c) Unofficial check of each dryer prior to official acceptance runs.

Dryers were shut down on May 26 for a two week period for inspection of the equipment and for the manufacturer to make some adjustments and changes before the official performance tests.

The official performance test is to determine the water evaporation capacity of each unit, total horsepower required per ton of dried solids and B. T. U. per ton of dried solids.

The dried sludge conveying system, storage hoppers, removal equipment and pelletizing equipment were operated the same time as the dryers. During this time the manufacturers made necessary changes and checked the operation of the equipment to conform to specification requirements.

8. Making Changes Required in Plant and Equipment.

Regardless of the care taken in the original design it is almost impossible to design a plant which can be placed in operation without several changes. It is the contractor's responsibility to construct the plant in accordance with approved drawings and specifications, but not to correct any errors or omissions in design. It is always necessary, therefore, to provide funds for corrections or additions. In our case funds were available partly from construction bond issues and partly from plant operating funds. The engineer must bring this matter to the attention of officials responsible for allocation of funds so that they may be prepared for these expenditures when the need arises.

9. Determination of Quantity and Character of Materials to be Handled.

The basic design factors of flow, sewage strength and quantities of sludge and other materials to be removed often do not agree with the actual quantities found in plant operation. These factors directly affect the cost of operation in the personnel required, the number of units operated, power consumed, chemicals required, materials and quantities handled, and other related costs.

Actual quantities and qualities should be determined as soon as possible and operating personnel and procedures adjusted accordingly. If necessary, steps should be taken to obtain additional funds.

10. Setting up Normal Operating Procedures.

The program for normal operation can be developed only after all basic factors are known and evaluated. Permanent duty assignments, operation, sampling and testing schedules can then be made. There should be a proper balance between sampling, testing and operating requirements but the sampling and testing program should be complete enough to give data for essential plant records as well as for control of plant operation. Preliminary forms should be reviewed and permanent forms prepared, preferable of standard size.

Summary

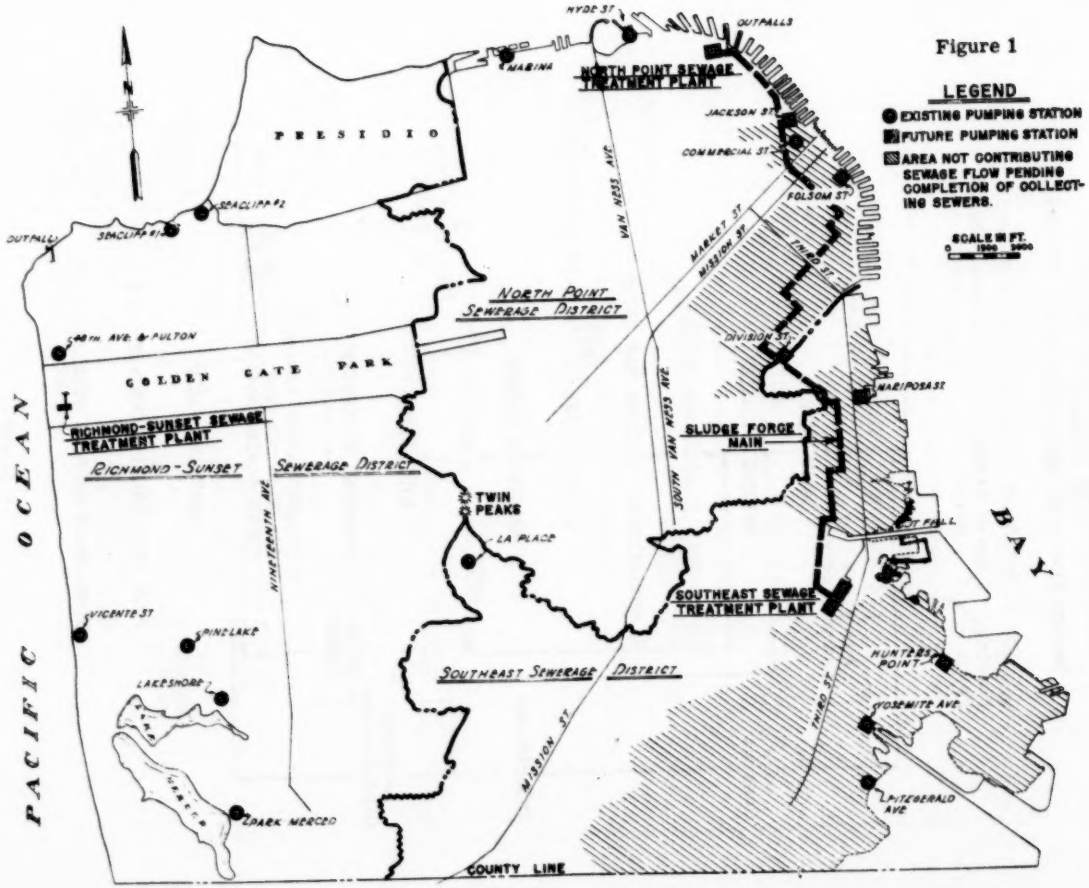
In retrospect the experience gained in starting these plants brings out certain salient points:

(a) It is necessary to consider operation in design.
(b) Consideration should be given to obtaining plant personnel sufficiently in advance of the starting date.
(c) An adequate training program is required.
(d) Steps should be taken to obtain adequate funds for operation in advance.
(e) An intimate knowledge of the plant and processes is needed by operating forces before starting.
(f) The design, inspection and operation forces should cooperate in checking the plant before and during initial operation.
(g) If possible, it is best to feel ones way by starting slowly rather than by placing all units in operation at full load at one time. This takes more time but is well worth it.
(h) It is essential to develop employee interest by making each person feel he has an active and important part.
(i) If possible, plants should be placed in operation when flow and other characteristics are normal.

ACKNOWLEDGEMENT

The plants are under the Division of Sewage and Waste Treatment Division of the Bureau of Engineering, Department of Public Works. Mr. Sherman P. Duckel, an A. S. C. E. is Director of Public Works, and Mr. Ralph G. Wadsworth, M. A. S. C. E. is City Engineer, R. H. Owens, A. M. A. S. C. E. is in charge of the Division of Design.

Figure 1


HYDE ST.
OUTFALLS
MARINA
NORTH POINT SEWAGE TREATMENT PLANT
JACKSON ST.
COMMERCIAL ST.
FOLSOM ST.
PRESIDIO
VAN NESS AVE.
MARKET ST.
MISSION ST.
HOWARD ST.
DIVISION ST.
SEACLIFF #2
SEACLIFF #1
OUTFALL
NORTH POINT SEWERAGE DISTRICT
48TH AVE. & FULTON
GOLDEN GATE PARK
MARIPOSA ST.
SLUDGE FORGE MAIN
RICHMOND-SUNSET SEWAGE TREATMENT PLANT
RICHMOND-SUNSET SEWERAGE DISTRICT
SOUTH VAN NESS AVE.
TWIN PEAKS
LA PLACE
PACIFIC OCEAN
BAY
VICENTE ST.
NINETEENTH AVE.
SPRING LAKE
LAKESHORE
SOUTHEAST SEWAGE TREATMENT PLANT
HUNTERS POINT
SOUTHEAST SEWERAGE DISTRICT
THIRD ST.
YOSEMITE AVE.
MISSION ST.
PITCHERALD AVE.
LAKE
MERCED
PARK MERCED
COUNTY LINE
LEGEND
EXISTING PUMPING STATION
FUTURE PUMPING STATION
AREA NOT CONTRIBUTING SEWAGE FLOW PENDING COMPLETION OF COLLECTING SEWERS.
SCALE IN FT.
0 1500 3000

NORTH POINT SEWAGE TREATMENT PLANT
FLOW DIAGRAM
Design Aver - 65 mgd - Max. Storm 150 mgd

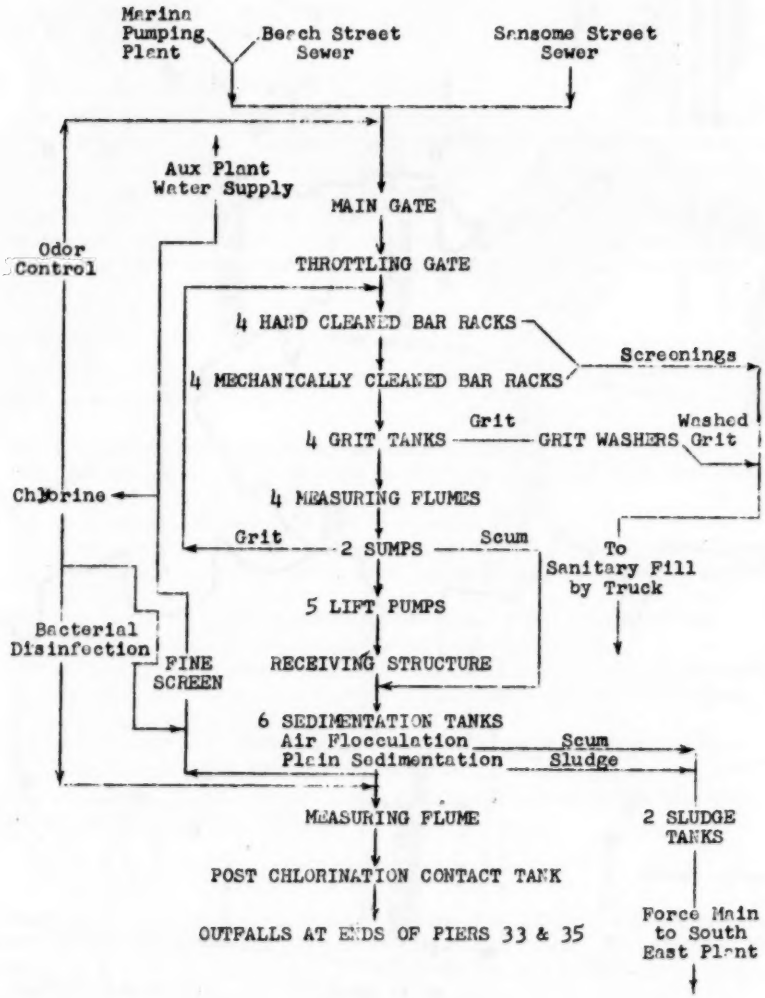


Figure 2

SOUTHEAST SEWAGE TREATMENT PLANT

SEWAGE FLOW DIAGRAM

Design Aver. - 30 mgd - Max Storm 70 mgd

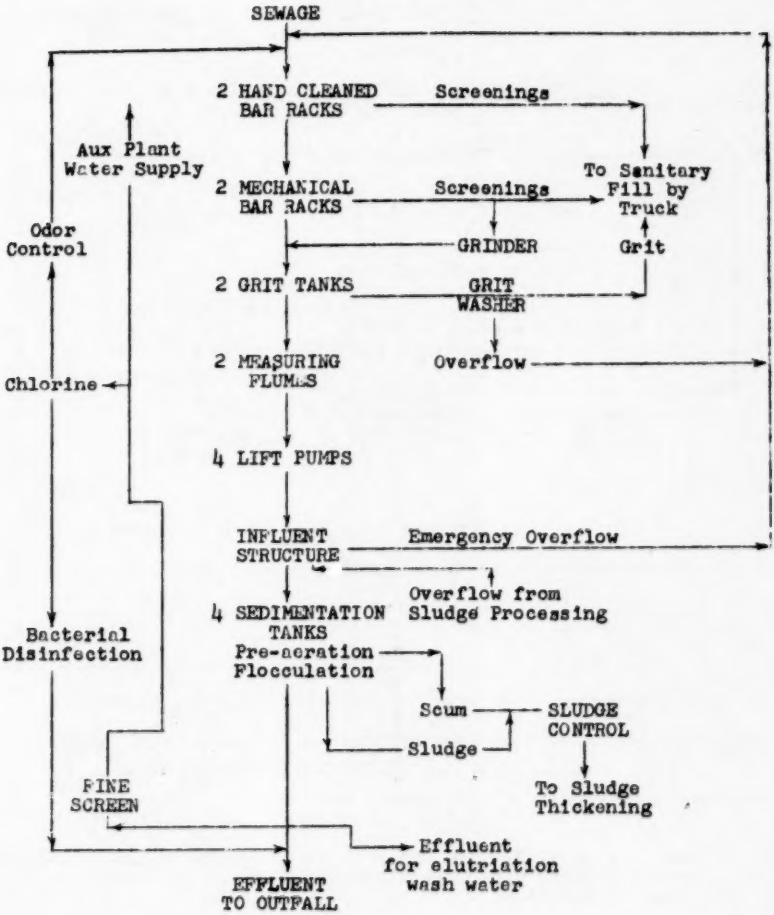
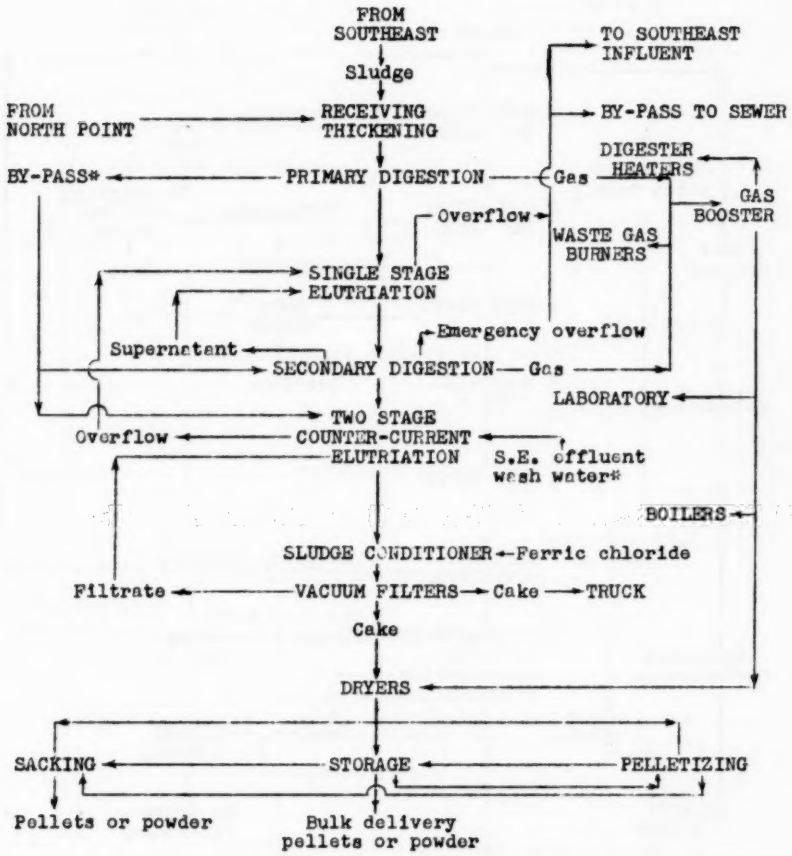


Figure 3

SOUTHEAST SEWAGE TREATMENT PLANT

SLUDGE FLOW DIAGRAM

Figure 4



* The lack of S. E. effluent made it necessary to use a limited amount of City water for elutriation and to by-pass single stage elutriation.

Figure 4

Fig. 4